SCIENCE 8

MODULE 1: Solutions and Substances

LEARNING FACILITATOR'S MANUAL

Distance Learning

Alberta
EDUCATION

Note

This Science Learning Facilitator's Manual contains answers to teacher-assessed assignments and the final test; therefore, it should be kept secure by the teacher. Students should not have access to these assignments or the final tests until they are assigned in a supervised situation. The answers should be stored securely by the teacher at all times.

Science 8
Learning Facilitator's Manual
Module 1
Solutions and Substances
Alberta Distance Learning Centre
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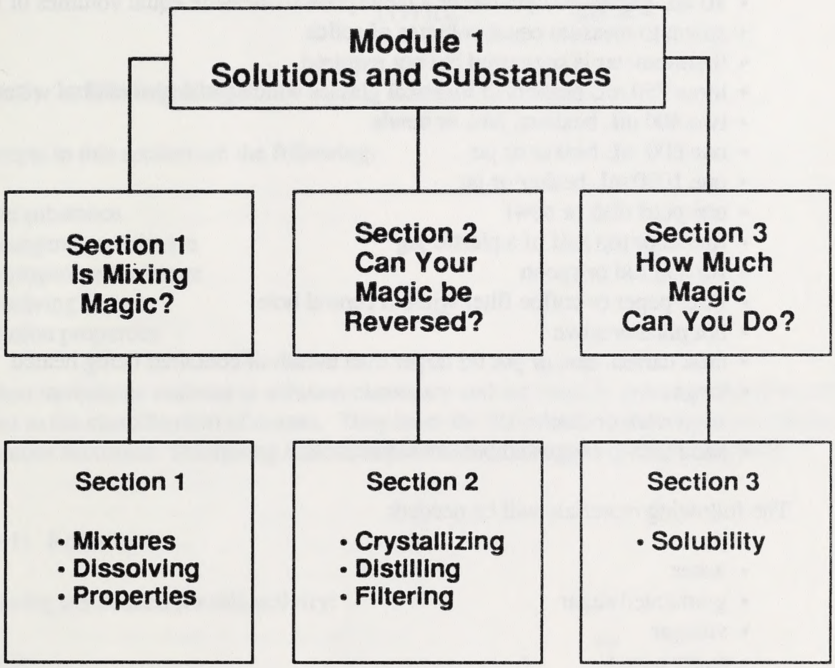
Module 1 – Solutions and Substances: Overview

The major emphasis of this module is the nature of science.

This module is an introduction to the study of solution chemistry. Students learn basic principles of solubility by investigating different kinds of solutions and their properties. The knowledge of solubility is applied to the separation of materials into component substances.



Classroom Opener

A discussion about the composition of materials could serve to introduce this module. The following could be compared with each other:

- oxygen, hydrogen, and air
- distilled water and seawater
- zinc, copper, and brass
- a cake and the ingredients listed in its recipe
- water, carbon dioxide, and pop

The discussion should develop the idea that many materials are composed of several substances.

Materials and Equipment

The equipment listed is for an individual or a group. Adjust the amount of equipment if more than an individual or group is involved.

The following equipment will be needed:

- seven test tubes with matching stoppers or medicine vials
- one test tube with matching stopper, or jar with a lid
- 10 mL graduated cylinder or a tablespoon to measure equal volumes of liquids
- spoon to measure equal volumes of solids
- thermometer is suggested but not required
- three 250 mL beakers or identical glasses which can withstand hot water
- two 400 mL beakers, jars, or bowls
- one 600 mL beaker or jar
- one 1000 mL beaker or jar
- one petri dish or bowl
- funnel or top half of a plastic jug
- stirring rod or spoon
- filter paper or coffee filter without central hole
- hot plate or stove
- milk carton, can, or pot lid larger than mouth of container being heated
- tongs
- stopwatch or clock
- hand lens is suggested but not required

The following materials will be needed:

- water
- granulated sugar
- vinegar
- sugar cubes
- cooking oil
- baking soda
- salt
- sand
- pepper
- ice
- food colouring
- solutes that change water's colour when dissolved (e.g. instant coffee)
- lemon juice

Evaluation

Your mark in this module will be determined by your work in the Assignment Booklet. You must complete all assignments. In this module you are expected to complete three section assignments. The assignment breakdown is as follows:

Section 1 Assignment	**40%**
Section 2 Assignment	**30%**
Section 3 Assignment	**30%**
TOTAL	**100%**

Section 1: Is Mixing Magic?

Key concepts in this section are the following:

- pure substance
- homogeneous mixture
- heterogeneous mixture
- dissolving factors
- solution properties

This section introduces students to solution chemistry and the inquiry process. Students are first introduced to the classification of matter. They learn the differences between homogeneous and heterogeneous mixtures. Dissolving factors and solution properties are also examined.

Section 1: Activity 1

The following are needed for this activity:

- water
- vinegar
- cooking oil
- salt
- pepper
- sugar
- baking soda
- seven test tubes with matching stoppers, or medicine vials
- 10 mL graduated cylinder, or a tablespoon to measure equal volumes of liquids
- spoon to measure equal volumes of solids

1. Look back at the list you brainstormed. Using that list, answer the following questions.

   a. How many products are solids?

   b. How many are liquids?

   c. How many are gases?

   d. How many of your substances do you consider dangerous?

   The answers will vary.

   Some common household products are the following:

   - *ammonia (liquid)*
   - *pepper (solid)*
   - *milk (liquid)*
   - *sugar (solid)*
   - *vinegar (liquid)*
   - *detergent (solid or liquid)*
   - *salt (solid)*
   - *natural gas (gas and dangerous)*

2. Explain the differences between a mixture and a pure substance.

   A mixture is made of more than one kind of matter.
   A pure substance has only one kind of matter.

3. List five main safety tips you should always follow in a science laboratory.

   Answers will vary. Some possible answers are given.

   - *Tie back loose hair.*
   - *Wear safety glasses when working with dangerous chemicals.*
   - *Do not wear baggy clothing to do experiments.*
   - *Be careful. Carelessness can cause accidents.*
   - *Assume substances are harmful unless your teacher tells you otherwise.*

Comment:

For the upcoming lab assignment encourage students to wear safety glasses, dust mask, rubber gloves, and a protective apron. While this is not necessary for these chemicals, students do need to be aware of what safety precautions can be taken when dealing with unknown materials. If the equipment is not available, at least discuss safety precautions.

4. **What is the problem given in Activity 1-2?**

   How can mixtures be classified?

5. **How do you think mixtures are classified?**

   Answers will vary. Since predictions are guesses, no student that addresses the question can have a wrong answer. A sample response is given. Mixtures can be classified as solids, liquids, or gases.

6. **Complete the chart as you make your mixtures.**

   Students may make some unusual observations. They may find an insect, for example. This exercise is to introduce dissolving. That is all that is to be recorded here. Inspect student charts to see if their observations are reasonable.

Mixture	Observations
water and vinegar	• *dissolving occurs* • *forms a clear liquid*
water and cooking oil	• *dissolving doesn't occur*
salt and pepper	• *dissolving doesn't occur*
sugar and baking soda	• *dissolving doesn't occur*
water and baking soda	• *baking soda dissolves* • *forms a clear liquid*
cooking oil and baking soda	• *dissolving doesn't occur*
salt and water	• *dissolving occurs* • *forms a clear liquid*
water and sugar	• *dissolving occurs* • *forms a clear liquid*
sugar and cooking oil	• *dissolving doesn't occur* • *The sugar settles.*

7. a. Name a solid substance that seemed to disappear when mixed with another substance.

   Three possible answers are baking soda, salt, and sugar.

   b. What was it mixed with?

   They were all mixed with water.

8. a. Name a liquid substance that seemed to disappear when mixed with another substance.

   A liquid substance that seemed to disappear when mixed with another substance was water.

   b. What was it mixed with?

   It was mixed with vinegar.

9. Name two mixtures where both parts were visible after mixing.

   There are four possible answers. They are as follows:

   - *water/cooking oil*
   - *salt/pepper*
   - *baking soda/cooking oil*
   - *sugar/cooking oil*

10. *Your mixtures were neither pure substances nor natural substances.* Explain why this statement is true.

    Answers will vary, but the key concept is the same as presented by the following:

    - *Mixtures cannot be pure substances.*
    - *Natural mixtures cannot be manufactured by humans.*

Section 1: Activity 2

The following are needed for this activity:

- sugar cubes
- water
- stopwatch or clock
- beaker or glass

1. What is a homogeneous mixture? Include the words *homogeneous*, *dissolve*, *solvent*, and *solution* in your answer.

   The answers should be a short paragraph. Students with weaker writing abilities should be given support. Assignment 1 will be marked for writing skills. This paragraph should include these points:

   - *Homogeneous mixtures are formed when a solute dissolves in a solvent.*
   - *Homogeneous mixtures are also called solutions.*

2. What is the difference between a solute and a solvent?

   Students should complete this question in full sentences. These concepts are to be addressed:

   - *The solute is the matter that is dissolved.*
   - *The solvent is the matter that does the dissolving.*

3. How do you know when a liquid solution has formed?

   Although a liquid solution may be coloured, it is always clear.

4. What are the three ways a liquid solution can form?

   All three ways of forming a liquid solution use a liquid solvent. The solute added to the solvent may be a solid, a liquid, or a gas.

5. What is the difference between an aqueous solution and a nonaqueous solution?

   The solvent is always water in an aqueous solution. In a nonaqueous solution the solvent is never water.

6. Give an example of an aqueous solution and a nonaqueous solution.

   Examples of an aqueous solution are tea and ocean water. Air and brass are examples of nonaqueous solutions.

7. Explain the difference between homogeneous and heterogeneous mixtures. Include the alternate name for each.

   Heterogeneous mixtures, also called mechanical mixtures, are formed when dissolving does not occur during mixing. Homogeneous mixtures, or solutions, are formed when dissolving does take place during mixing.

8. Classify some of the solutions you have just found as either natural or human-made. Complete the chart so that you have six examples of each kind of solution.

Answers can vary. A sample response follows.

Natural Solutions	Human-made Solutions
tears clear air *sweat* *saliva* *urine* *untreated water*	clear apple juice *water and methanol* *vinegar* *tea* *bronze* *clear shampoo*

9. Use your observations from Step Five in Activity 1. Decide if the solute was soluble or insoluble. Classify each mixture as being either homogeneous (a solution) or heterogeneous. You may leave the boxes blank for the two mixtures not completed in Activity 1.

Mixture	Soluble or Insoluble	Homogeneous or Heterogeneous Mixture
water and vinegar	*soluble*	*homogeneous*
water and cooking oil	*insoluble*	*heterogeneous*
salt and pepper	*insoluble*	*heterogeneous*
sugar and baking soda	*insoluble*	*heterogeneous*
water and baking soda	*soluble*	*homogeneous*
cooking oil and baking soda	*insoluble*	*heterogeneous*
salt and water	*soluble*	*homogeneous*
water and sugar	*soluble*	*homogeneous*
sugar and cooking oil	*insoluble*	*homogeneous*

10. Which mixtures were aqueous solutions?

    The following are aqueous solutions:

    - *water and vinegar*
    - *water and baking soda*
    - *water and salt*
    - *water and sugar*

11. None of the mixtures were nonaqueous solutions.

    Give an example of a nonaqueous solution.
    Answers can vary. Some nonaqueous solutions are air, brass, bronze, and crude oil.

12. For each of the homogeneous mixtures identified, name the solute and solvent. Put a cross in the Solute and Solvent boxes if the mixture is a heterogeneous mixture. Leave the boxes blank for the two mixtures you did not make.

Mixture	**Solute**	**Solvent**
water and vinegar	*vinegar*	*water*
water and cooking oil	*X*	*X*
salt and pepper	*X*	*X*
sugar and baking soda	*X*	*X*
water and baking soda	*baking soda*	*water*
cooking oil and baking soda	*X*	*X*
salt and water	*salt*	*water*
water and sugar	*sugar*	*water*
sugar and cooking oil	*X*	*X*

Section 1: Activity 3

The following are needed for this activity:

- sugar cubes
- hot and cold water
- thermometer if available
- two identical glasses or beakers

1. Think about the situation. There are three possible problems that could be investigated by experiment. Each of these relates to dissolving. One of these is given to you. What are the other two?

   a. What effect does temperature have on the dissolving rate of sugar?

   b. *What effect does the particle size have on the dissolving rate of sugar?*

   c. *What effect does the mechanical movement of the water have on the dissolving rate of sugar?*

2. Write your hypotheses for the three possible investigations.

   a. *As temperature increases, the dissolving rate of sugar increases.*

   b. *As particle size increases, the dissolving rate of sugar decreases.*

   c. *As mechanical movement increases, the dissolving rate of sugar increases.*

   A hypothesis calls for a validated prediction. The students must be able to explain why they think their hypothesis is correct. The student hypothesis should reflect knowledge learned thus far in this section. If a student can back up a prediction with facts, then the hypothesis is correct.

3. Write the procedure you are going to follow to test your hypothesis.

   By Grade 8 most students have been introduced to manipulated, responding, and controlled variables. These concepts will be addressed in Section 3 of this module. The problem shows that the manipulated variable is the temperature of water. The dissolving time of the sugar cube is the responding variable. Two controlled variables are the amount of mechanical movement and particle size. Both factors are kept constant. Other controlled variables are indicated in the sample procedure. Students do not have to acknowledge these variables formally, but their procedure should reflect an understanding of variables. If the student response to this question indicates a lack of understanding of the science inquiry process, give support at this point. A sample procedure is given.

   - *Fill one glass with hot water.*

   - *Fill an identical glass (controlled variable) with cold water.*

- *Take two sugar cubes from the same box (controlled variable) and drop one in each glass at the same time (controlled variable).*

- *Watch to see whether the hot water or cold water dissolves the cube faster. Record your results.*

An alternative approach would be to make two trials. One trial would be to use hot water, the other cold water. Using this approach, the dissolving times for both trials would be timed and recorded.

4. Draw the chart you designed. As you follow your procedure, enter your results in the chart.

   Charts will vary, but they must include dissolving rate (time) and temperature of water. If students used a method similar to the example given, they will use relative time (faster/slower).

5. What effect does temperature have on the dissolving rate of sugar?

   As water temperature increases the dissolving rate of sugar in that water increases.

6. Was your hypothesis correct? Explain.

   If experimental evidence does not support an original hypothesis, a scientist has learned something. Give support to students who cannot explain why their hypothesis was wrong.

7. There are three dissolving-rate factors. State what these three factors are. Explain how each factor influences the dissolving rate of a solute.

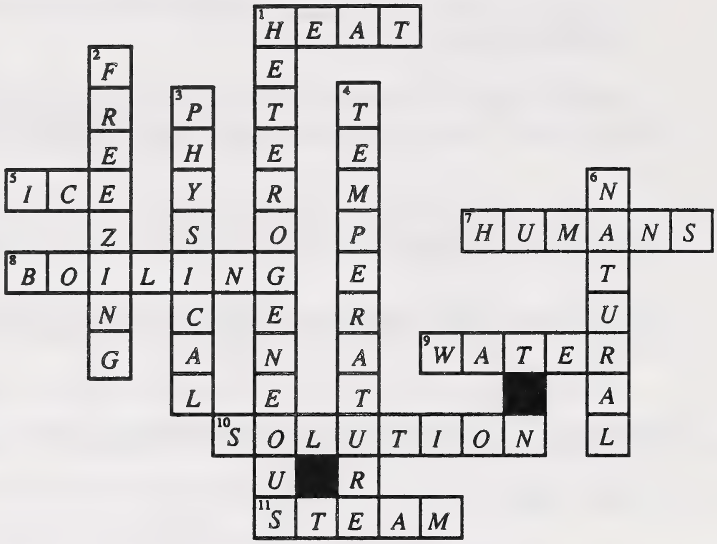
   The three factors that affect dissolving rate are temperature, particle size, and mechanical movement.

   - *As the temperature of the solute increases, the dissolving rate decreases.*

   - *As the particle size of a solute increases, the dissolving rate decreases.*

   - *As the mechanical movement increases, the dissolving rate of the solid (sugar) also increases.*

8. The puzzle will give you an opportunity to review many of the new terms you have learned in this module. Complete the puzzle.



9. People drink a variety of liquid solutions. Over the next two days keep a list of the liquid solutions you see people drinking. Fifteen or twenty minutes will be all it will take to do this exercise. There is no need to search very hard. Liquid solutions are very common. Along with your list, keep track of the colours and any other unusual characteristics that the liquid solutions have.

Answers can vary. One response is shown in table form.

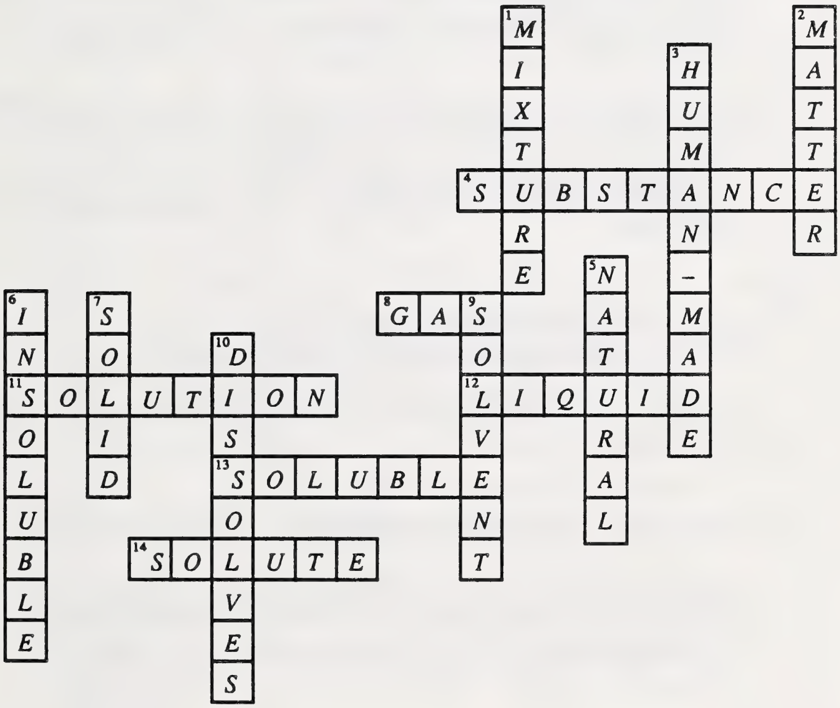
Beverage	Colour	Other
coffee	dark brown	–
tea	brown	–
lemonade	light yellow	–
pop	colourless	bubbly

Section 1: Activity 4

The following are needed for this activity:

- water
- three 250 mL beakers or glasses
- stirring rod or spoon
- solutes that change water's colour when dissolved

1. Complete the following puzzle.



2. All types of matter can be solid, liquid, or gas. Water has three different names depending on whether it is a solid, liquid, or gas. Write these names and indicate whether the name refers to solid, liquid, or gaseous water.

   The names and states of each are as follows:

   - *ice – solid water*
   - *water – liquid water*
   - *steam or water vapour – gaseous water*

3. An increase in temperature can change solids to liquids. What other changes can a change in temperature make? Before you answer this question, ask yourself, "Does temperature only increase?"

   - *A temperature increase can change liquids to gases.*
   - *A temperature decrease can change gases to liquids.*
   - *A temperature decrease can change liquids to solids.*

4. Write a paragraph based on your observations. For each solute used, describe the physical appearance of the solution containing that solute. If you are working at home, consider making solutions that are safe to drink. If you do so, you will have something to enjoy while you write your paragraph.

   The answers to this question will be varied. Colour is the physical property of solutions being studied, and student paragraphs should reflect this. Food colouring, clear juices, coloured crystals, or coloured powders are examples of substances that can change the colour of water. Assignment 1 gives marks for writing skills. Give students with weaker writing abilities support at this point.

5. At sea level the boiling point of water is 100°C.
   What can happen to that boiling point if a solute is added?

   When the solute is added, the boiling point may increase, decrease, or remain constant depending on the solute.

6. Why is salt used on roads in the winter time?

   Salting roads is done to prevent accidents due to icy conditions. Salt lowers the freezing point of water up to 15°C. When added to wet roads, salt prevents the formation of ice when the temperature drops below 0°C. When salt is added to icy roads, the salt causes the ice to melt if the temperature is above –15°C.

Section 1: Follow-up Activities

Extra Help

1. Complete the following table.

Answers will vary. One response is shown.

Term	Meaning and Example
soluble solution	• *dissolves in a solvent* • *salt dissolves in water*
aqueous solution	• *a solution that uses water as a solvent* • *sugar water*
insoluble solute	• *does not dissolve in a solvent* • *sugar does not dissolve in cooking oil*
nonaqueous solution	• *a solution that does not use water as the solvent* • *air, brass*
heterogeneous mixture	• *a mixture in which the parts are distinguishable* • *sand and iron filings*
natural nonaqueous solution	• *a solution not made by humans that does not use water as the solvent* • *clean air*
human-made aqueous solution	• *a solution made by people that uses water as the solvent* • *tea, sugar water, salt water*

Enrichment

1. Imagine that it is spring time. You live on a farm in northern Alberta. Most of your community's business depends on tourism. You have a huge pond on your property. Experts have told you that your livestock will never be able to drink from the pond. Financially, you are almost broke. If you do not make money soon, you are going to lose your farm. From what you have learned about solutions and their physical properties, create a use for the pond that will attract tourists.

   The answers to this question will be varied. Physical properties of solutions were mentioned in the question, therefore these properties should be incorporated into the answer. A few samples of possible student responses follow.

   - *Colour is the physical property of solutions that could be used to attract tourists to the pond.*
   - *Depending on the solute added, the pond could be made any colour.*
   - *The colour of the pond could be changed to attract new and repeat business.*
   - *Winter ice skating on coloured ice would be intriguing to winter sport enthusiasts.*
   - *Adding the right solute could lower the freezing point of the water. Tourists would find it intriguing to go boating in a coloured pond when the other water surfaces were frozen.*

   Assignment 1 gives marks for writing skills. Give students with weaker writing abilities support at this point.

2. Your project might affect others. What environmental considerations should you make before proceeding?

   The answers to this question will be varied. Students of this age are generally concerned about pollution. Sample responses follow.

   - *The solutes added could kill plants and animals in the pond.*
   - *The solutes could be toxic. People might get sick or even die from drinking the water.*

Section 1 Assignment

1. What is water?

   Write a paragraph using at least ten of the following words. Your paragraph will need to include three parts (introduction, body, and conclusion).

   Answers can vary. Sample sentences using the terms are given.

   - matter: *Water is one kind of matter.*

- pure substance: *Distilled water is a pure substance.*
- mixture: *Water is a mixture of substances.*
- homogeneous mixture: *Salt and water combine to form a homogeneous mixture.*
- heterogeneous mixture: *Sand and water form a heterogeneous mixture.*
- solute: *Salt can be the solute in an aqueous solution.*
- solvent: *Water is the solvent in an aqueous solution.*
- aqueous solution: *Aqueous solutions are formed when water is the solvent.*
- nonaqueous solution: *Nonaqueous solutions are formed when water is not the solvent.*
- soluble: *Sugar is soluble in water.*
- insoluble: *Cooking oil is insoluble in water.*
- physical appearance: *Adding tea can change the physical appearance of water.*
- boiling point: *Adding solutes can change the boiling point of water.*
- freezing point: *Adding solutes can change the freezing point of water.*
- natural solution: *The ocean is a natural solution.*
- human-made solution: *Sugar water is a human-made solution.*

The following marking scheme may be found useful.

For each category, decide if the student's work is poor, excellent, or somewhere in-between. A mark is assigned according to this decision.

Category	Student Performance Poor					Excellent
Term Usage	0			1		2
matter	0			1		2
pure substance	0			1		2
mixture	0			1		2
pure substance	0			1		2
homogeneous mixture	0			1		2
heterogeneous mixture	0			1		2
solute	0			1		2
solvent	0			1		2
aqueous solution	0			1		2
nonaqueous solution	0			1		2
soluable	0			1		2
insoluable	0			1		2
physical appearance	0			1		2
boiling point	0			1		2
freezing point	0			1		2
natural solution	0			1		2
human-made solution	0			1		2
Spelling/Punctuation	0	1			2	3
Grammar	0			1		2
Organization	0	1	2	3	4	5
Total				/30		

2. *Mixing is magic.* Explain why this statement is true using the following terms: *dissolving, soluble, insoluble, solution, solute,* and *solvent.*

   Student's responses to this question will vary. A possible response is given.

   A successful magician can make a dove disappear from the audience's view. When soluble substances are used, the solvent acts like the magician and makes the solutes disappear. For example, when a teaspoon of sugar is placed in a glass of warm water, the sugar dissolves from view. As with a magician's disappearing act, the dissolved sugar is hidden from view. It is still there, but you cannot see it. Sometimes a magician does his trick poorly and the dove does not disappear. Insoluble substances are like uncooperative doves. They refuse to disappear when the dissolving act is attempted.

   A total of ten marks can be given for this question. One mark can be assigned for each term correctly used. Two marks can be given for grammar and spelling. The other two marks can be given for the student's success in making the analogy between solutions and magicians.

Section 2: Can Your Magic Be Reversed?

Key concepts in this section are the following:

- settling
- filtration
- evaporation
- crystallization
- distillation

This section introduces students to the practical science of separating mixtures. It has two parts. In the first part of the section, students have the opportunity to separate heterogeneous mixtures using the techniques of settling and filtration. In the second part of the section, distillation and evaporation are used by the student to separate homogeneous mixtures.

Section 2: Activity 1

The following are needed for this activity:

- 600 mL beaker or jar
- four teaspoons of sand
- water
- spoon or stirring rod
- test tube and stopper, or jar with lid
- petri dish or bowl
- funnel or top half of a plastic jug
- filter paper or large coffee filter
- two beakers, jars, or bowls
- food colouring

1. What separation procedure is shown?

   Settling is the separation procedure shown.

2. Explain how to separate using this method.

   When particles are too heavy to be suspended by a liquid they fall to the base of the container. When these heavy particles have accumulated at the bottom of the container, the liquid can be poured out. The heavy particles have been separated from the mixture by a process called settling.

3. What separation procedure is shown?

   Filtration is the separation procedure shown.

4. Explain how to separate using this method.

   To separate a mixture by filtration you need a funnel and some type of filter. Paper filters are commonly used, but pebbles and sand can also be used to make an effective filter. The filter is placed inside the funnel. The mixture is poured into the paper filter. The filtrate is collected in a container. The residue is collected from the filter paper.

5. Great plans seldom come without thinking. Use one of the two filtering methods you have already learned, or design your own. Explain your plan. You may draw a model if that will make it easier.

   Answers will vary. A sample plan is given.

   - *Put two teaspoons of sand into 200 mL of water.*
   - *Stir the mixture.*
   - *Insert a filter into the funnel.*
   - *Pour the mixture slowly into the filtration apparatus.*
   - *Collect the filtrate and the residue.*

6. Did your design work better than the settling process? Explain.

   Very fine dirt particles do not settle. Students should find that their filtration sample is clearer than the one collected by settling.

7. Why does the dye go through your filter with the water?

The dye particles must be smaller than the holes in the filter.

Some students may ask questions about the size of particles. The program of studies does not include the particle theory of matter. To answer questions concerning particle size you may want to address the particle theory briefly. The text, ***Science Directions 8****, explains this theory on pages 4 and 5.*

Section 2: Activity 2

The following are needed for this activity:

- water
- hot plate or stove
- beaker or pot
- milk carton, can, or pot lid larger than mouth of container being heated
- ice
- food colouring
- salt
- tongs

Comments:

It is recommended that distillation of a coloured solution be demonstrated as in the text, **Science Directions 8**, Activity 1-10 on page 29. Note that the materials for this demonstration are not included in the preceding list. Finding Out, questions 1-5, may be discussed with your students. Responses to these questions follow.

Textbook question 1. *Answers vary according to the starting solution.*

Textbook question 2. *The residue colour will intensify and it may appear to be thicker due to the loss of water.*

Textbook question 3. *The distillate should be colourless and look like water.*

Textbook question 4.
- a. *The distillate seems to be water removed from the solution.*
- b. *The solute remains in the flask and the solvent has been caught in the test tube. Therefore, both have been recovered.*

Textbook question 5
- a. *The distillate was a gas.*
- b. *Two changes of state occurred.*
- c. *Vapourization occurred in the flask. Condensation took place in the test tube.*

Students should be closely supervised for Activity 2. Hot materials are involved.

1. Explain how distillation works.

   The distillation process has two parts. First the liquid mixture is heated to increase the evaporation of one of the mixture's components. Then this evaporated component is condensed and collected.

2. Think over your alternatives. Draw a picture of the design you decide to use for distillation.

   Answers can vary. This exercise was designed to allow alternatives for the students. The simplest method is to use a saucepan and lid. When the pan containing the aqueous solution is heated, the evaporated water condenses on the lid. The lid can be tipped to collect the distillate in a separate container. Several other alternatives were given in the Study Guide. Creative students may invent their own procedure. Student safety is the only constraint for this exercise.

3. Describe the steps you plan to follow.

   Answers can vary. A sample plan follows.

   - *Place 200 mL of solution in the pan.*
   - *Turn the heat on high.*
   - *When the solution starts to steam (nears the boiling point), place the lid (or container filled with ice) over the pan. Use tongs to hold the lid.*
   - *Occasionally tip the lid so that the condensed distillate can be collected in a separate container. If containers filled with ice are used, they are placed over another container. The condensed distillate will drip into the container underneath.*

   An oversized lid will collect more distillate. Lab facilities usually have tongs. If these are not available, barbecue tongs can be used. Alternately, a wooden spoon can be pushed through a milk carton. Students can safely hold this over the pot even when the container is filled with ice. Creative students may want to make their own. Check these designs for safety before allowing students to use them.

4. Test your design for safety before you attempt to distill your solution. Report any changes that you have to make.

   Answers will vary. This step was added to make students think about how to handle materials safely. A few practice runs before using the boiling water would be advised.

5. Evaluate your design and planning process. Be sure to give proof that your design worked.

   The methods described are not efficient. Students should recognize this fact. Some may come up with alternatives to increase their distillation efficiency.

   When compared to the original 5 mL sample saved, the solution in the pan will turn a darker colour as the distillate escapes. The second part of the proof is that the distillate is clear. If the distillate has been cooled and sterile equipment has been used, tasting can be a third way of proving the process works. The distillate is pure water. It will not taste salty.

   If students are encouraged to taste the distillate, emphasize that this is not a common practice in solution chemistry.

6. List three examples of how evaporation or distillation is used in nature, or by humans, to separate solutes from solutions.

   Answers will vary. Some examples are given.

   - *The water cycle depends on evaporation and condensation.*
   - *Salt water can be evaporated by people and/or nature to obtain the salt.*
   - *The oil industry uses fractionating towers to separate crude oil into its components (e.g. propane and butane).*
   - *Wet sand, grass, and dirt in the garden are dried by evaporation.*
   - *When you wash your bike and do not dry it, nature does it for you by evaporation.*

Section 2: Activity 3

The following are needed for this activity:

- the 5 mL coloured salt water solution from Activity 2
- hand lens is suggested
- sugar water
- lemon juice

1. Finish the story.

   Answers for this will vary. A few possible condensed endings follow.

   - *The house is haunted. When someone enters with greedy intentions that person turns into a precious stone. The room full of gems indicates that many greedy people had gained entrance to the room.*

- *The student collects the precious stones and becomes the wealthiest kid in the world. The student shares the wealth with friends and lives happily ever after.*

2. How can evaporation cause crystals to grow? Include the name of the process in your answer.

   As the solute is condensed by evaporation the solute particles join together in a regular pattern. The outside edges form flat surfaces.

Comment:

As a point of interest you may tell students that crystals from the same substance come in a variety of sizes. The shape of the crystals, whether large or small, remains the same.

3. Why does water from various places often taste different?

   Pure water is tasteless. Water gains its distinctive taste from the solutes it dissolves.

4. How does a kidney stone form?

   Kidney stones are formed in urine. Solute particles join together by the crystallization process. If the kidney stone is very large, medical attention is required.

5. Report your findings.

   Salt crystals are shaped like cubes. Dice have the same shape. The crystals will be the same colour as the dye that was used.

Section 2: Follow-up Activities

Extra Help

1. Complete the chart.

Separation Method	Explanation of How This Method Works
Settling	Heavy particles fall to the bottom of the container. Then the liquid is poured off.
Filtration	*The mixture is poured through a filter. Smaller particles pass through the filter. Larger particles are trapped by the filter.*
Evaporation	*A liquid turns from a liquid to a gas. The remainder of the mixture is left behind.*
Distillation	*A liquid is evaporated. The gas is condensed and collected. The remaining part (residue) can be collected following the distillation process.*
Crystallization	*As solutions evaporate, solute particles join together in regular patterns. The outside surfaces of the crystal are flat.*

2. Give an example of a mixture that you could separate using each of the methods indicated.

   Answers will vary. Sample answers are provided.

   a. Crystallization

      Sugar water could be separated by crystallization.

   b. Filtration

      Spaghetti and water can be separated by filtration using a colander.

   c. Settling

      Dirt and water can be separated by settling if the dirt particles are heavy enough.

   d. Distillation

      Baking soda and water could be separated by distillation.

e. Evaporation

Coffee and water can be separated by evaporation. Students that have washed coffee cups where all the water has evaporated from the mixture will be able to identify with this example. The stain left by the residue is not appealing.

Enrichment

You are the local town's environmental consultant. The town's drinking water has suddenly turned muddy, and you need to present to town council possible alternatives to remedy the problem. You were not asked to investigate the cost of each alternative. That is the responsibility of the engineering department. Town council has requested that you present at least three alternatives for review.

For each alternative, give the name of the separation process and how it could solve the muddy drinking water dilemma.

Answers will vary. A sample answer is given.

The water can be placed in a container. If the dirt particles are large enough, gravity will pull them to the bottom of the container. The process is called settling. The water can be drained off leaving the heavier mud particles behind.

If the water is not clean enough, it can be filtered by a process called filtration. The water is poured through a device that will not allow the mud particles through. Pure water can be obtained by distillation. In this process the water would be allowed to evaporate. The evaporated water would be collected and condensed.

Section 2 Assignment

1. Imagine that you have been assigned the task of separating an aqueous solution. You must collect both parts of the mixture. In a paragraph, explain what separation process you would use and how you would carry out the process.

   Answers will vary, but here is a guide to assist in grading this question out of a total of eight marks.

   - *The name of the process is worth two marks. Give one mark if evaporation is given, since the distillate will not be recovered in this process. Give two marks if distillation is the separation name given, since the distillate will be recovered.*

   Marks may be assigned as indicated in the brackets for the remaining six marks.

   - *Heat the mixture (one mark) to increase the evaporation rate (one mark).*

   - *Collect (one mark) and condense (one mark) the distillate.*

- *Describe the appropriate equipment to be used (two marks), (e.g. holding an ice-filled milk carton over a boiling pot).*

2. You have become a separation expert. Imagine that your neighbour's sand box has been vandalized. During the night a prankster added 25 kg of woodshavings to the sand. It was well stirred so it is impossible to pick the shavings out one at a time. Your neighbour's child is hysterical. The child wants to play in the sand box but cannot. What method of separation is most appropriate to solve this problem? Explain how the separation could be made.

   Answers will vary, but here is one guide to assist in grading this question out of a total of eight marks.

   - *The name of the process is worth two marks. Give one mark if filtration is used. This process would not be very practical. Settling is worth two marks because it is the most practical method. Assign marks as indicated in the brackets for the remaining six marks.*
   - *Use a large container filled with water (one mark).*
   - *Pour the mixture (sand and wood shavings) into the water (one mark).*
   - *Allow the sand to settle (one mark).*
   - *Since wood shavings float (one mark), scoop out the wood shavings from the water's surface (one mark).*
   - *Drain the water and return the sand (one mark).*

3. *Many types of heterogeneous mixtures can be filtered. Homogeneous mixtures cannot be filtered.*

   Explain why these two statements are true.

   Answers will vary, but here is one guide to assist in grading this question out of a total of five marks.

   - *The components of a heterogeneous mixture are distinguishable (one mark).*
   - *If there is a big difference in the size of particles (one mark), then a filter system can be set up to separate them (one mark).*
   - *In homogeneous mixtures the components are not distinguishable (one mark).*
   - *Filters cannot be made with holes small enough to separate these mixtures by particle size (one mark).*

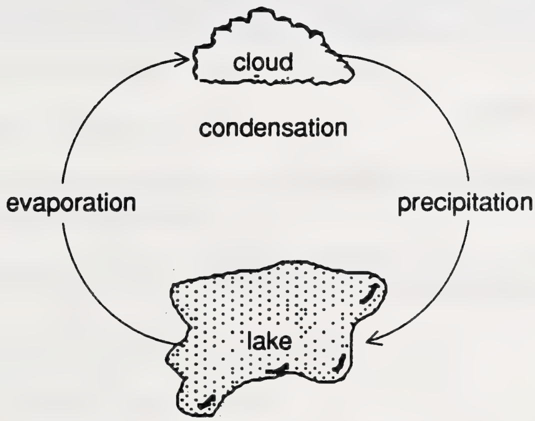
4. You can find out about the water cycle in many reference books. You may have to go to your local library. Find a picture that illustrates the water cycle.

Answers will vary, but here is a guide to assist in grading this question out of a total of nine marks.

a. Draw your own picture to illustrate the water cycle.

A sample water cycle is shown. Four marks can be given as indicated by the following.

- *A water body (one mark) must be included to show where evaporation (one mark) occurs. A cloud must be visible to show vapour condensing (one mark). Precipitation (one mark) falling from the cloud is the final component.*



b. The water cycle works like one of the separation techniques that you learned about in this section. In a paragraph, name this separation technique and then compare this technique to the water cycle.

Five marks can be given.

- *The name of the process can be worth two marks. Give one mark if evaporation is given, since this process does not allow for the cycle to continue. Give two marks if distillation is the process named.*

Marks can be assigned as indicated in the brackets for the remaining three marks.

- *In both processes a liquid is evaporated and condensed (one mark).*
- *The water cycle returns the liquid to its original "container" to start the process over again (one mark), but the distillation process does not begin again (one mark).*

Section 3: How Much Magic Can You Do?

Key concepts in this section are the following:

- variables
- concentration
- saturation point
- solubility
- graphing

This section has two parts. In the first part, students are introduced to the variables used in science inquiry. They use this new knowledge to study solubility informally. In the second part of the section, solubility terminology is presented. Students then study the effects of temperature on solute solubility. They are shown how to graph results to help process the data they collect. The intent of this section is to enhance the students' ability to design their own experiments.

Section 3: Activity 1

The following are needed for this activity:

- water
- three 250 mL beakers or identical glasses
- thermometer is suggested
- salt
- sugar

1. What are manipulated, responding, and controlled variables?

   Manipulated variables are experimental changes made by humans. Responding variables are nature's reaction to human manipulation. Controlled variables are factors that could change, but are not allowed to change during a scientific experiment.

2. In an inquiry experiment a scientist makes at least two trials. Why?

   In the first trial, nature is studied without human manipulation. In the second trial, a manipulation is made. Nature's response is studied. The second trial gives the scientist the ability to compare natural responses with manipulated responses.

3. What is the problem shown in the previous graphic? Use the "What effect does ____________ have on ____________ ?" format.

   What effect does heat have on the temperature of water?

4. What is the problem?

   What effect does the type of solute have on the amount of solute that can dissolve?

5. Write a prediction that answers the problem.

   Answers will vary, but some sample predictions are given.

   - *The type of solute will not affect the amount of solute that can dissolve.*
   - *More salt will dissolve in water than sugar.*
   - *More sugar will dissolve in water than salt.*

6. Write down an appropriate procedure to test your prediction. You will have to measure the amount of solute you add carefully. A tablespoon should be used to measure the solute and 100 mL of water should be used for each of the solutions.

   Answers will vary. A sample procedure follows.

   a. *Add a level tablespoon of salt to 100 mL of water. (The solute should be added gradually in portions of a tablespoon.)*

   b. *Stir until all of the salt is dissolved.*

   c. *Continue a. and b. until no more salt will dissolve.*

   d. *Record the amount of salt dissolved.*

   e. *Repeat a. through d. using sugar instead of salt. Make sure the temperature and the amount of water is the same in this second trial.*

Comment:

If a thermometer is not available for this experiment, have the student set out a container of water to reach room temperature. The temperature of the water will be approximately 20°C or similar to the thermostat reading.

7. Show your chart with your recordings entered.

Type of Solute	Amount of Solute Dissolved (tablespoons/100 mL)	Temperature
salt	1.5	20°C
sugar	2	20°C

8. Explain what your results demonstrated. Make sure to indicate whether your prediction was correct.

   Students should discover that water dissolves more sugar than salt at the temperature used (20°C).

Section 3: Activity 2

The following are needed for this activity:

- water
- thermometer (if possible)
- hot plate or stove
- three 250 mL beakers or identical glasses that can withstand hot water
- salt
- sugar
- spoon (about the size of a tablespoon)

1. Explain the meanings of concentration, saturation point, and solubility.

   Concentration is the measure of the amount of solute that is in a given amount of solvent. The saturation point is reached when no more solute can dissolve in a solvent. Solubility is a measure of the maximum amount of solute that will dissolve at the saturation point at a particular temperature.

2. How are you going to measure concentration in this module?

   In this module students will measure concentration by the number of tablespoons of solute in 100 mL of water.

3. Explain how solubility, concentration, and saturation point relate to the experiment you did in the last activity.

   Answers will vary. A sample follows.

   The concentration of the solute dissolved in water was increased until the saturation point was reached. At 20°C the solubility of salt in water was 1.5 tablespoons/100 mL of water. The solubility of sugar was 2 tablespoons/100 mL of water at the same temperature. Water at this temperature has a higher saturation point for sugar than for salt.

4. What are the similarities and differences between dissolving rate and solubility?

   Dissolving rate is the speed at which a solute dissolves, while solubility is the measure of the maximum amount of solute that will dissolve at a given temperature. Both terms relate to dissolving. Dissolving rate and solubility for most solutes increases with increasing temperature.

5. How can you use your knowledge of solubility to grow your own crystals?

   Answers can vary. One response follows.

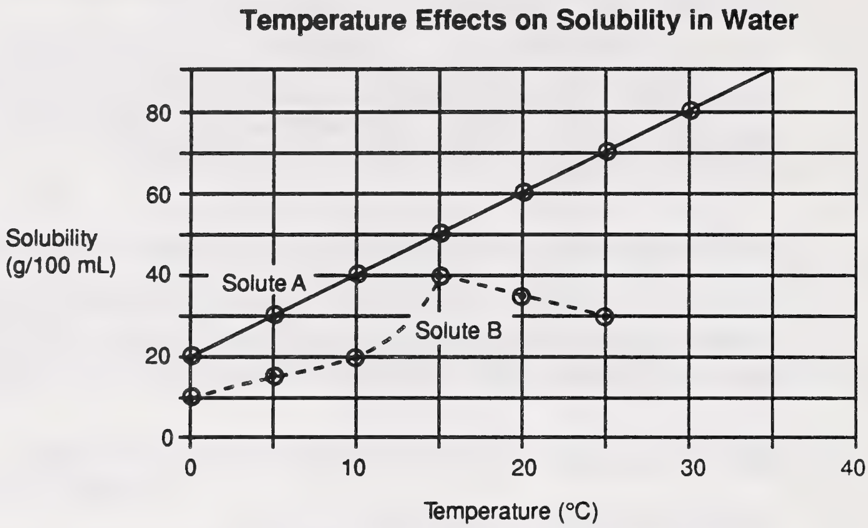
   Dissolve a solute in a hot solvent until the saturation point is reached. Tie a paper clip to a string. Attach the string to a pencil so that the paper clip is suspended in the solution. Allow the solution to cool. Crystals should form on the string. Crystals often grow very slowly, so allow plenty of time.

6. Use your graphing knowledge to complete the graph that follows.

   a. Determine and write in the label for the vertical axis.

      On the graph the vertical axis is reserved for the responding variable. The responding variable for this experiment is solubility. The units to be used for solubility are g /mL.

b. Using the charts that follow, plot the remaining points for the two solubility curves. Draw a straight line or smooth curve to complete the solubility curves. Use a different colour for each solute.



The student's extrapolation should be similar to the previous graph.

7. Write a hypothesis that answers the problem.

The information presented indicates that solubility increases when temperature is increased for most substances. If students use this information, their hypotheses will state that the solubilities for both sugar and salt will increase when water temperature is increased.

Comments:

- Students should be closely supervised for the experiment that follows. Hot materials are involved.
- Please note that for some students obtaining a suitable thermometer may be difficult. For this activity the solubility curves for salt and sugar are so different that students should estimate their temperatures as 25°C for cold, 70°C for warm, and 100°C for hot. The solubility trends can still be seen using these roughly estimated temperatures. However, it is preferable that students have the opportunity to measure temperature.

8. Record your data in the following charts.

Students may give solubilities to the nearest whole number of tablespoons. If the solute has been added gradually, students should be able to give a reliable estimate to the nearest one-half of a tablespoon. Although solubility values may vary, the trends shown in the following tables should be evident.

a.

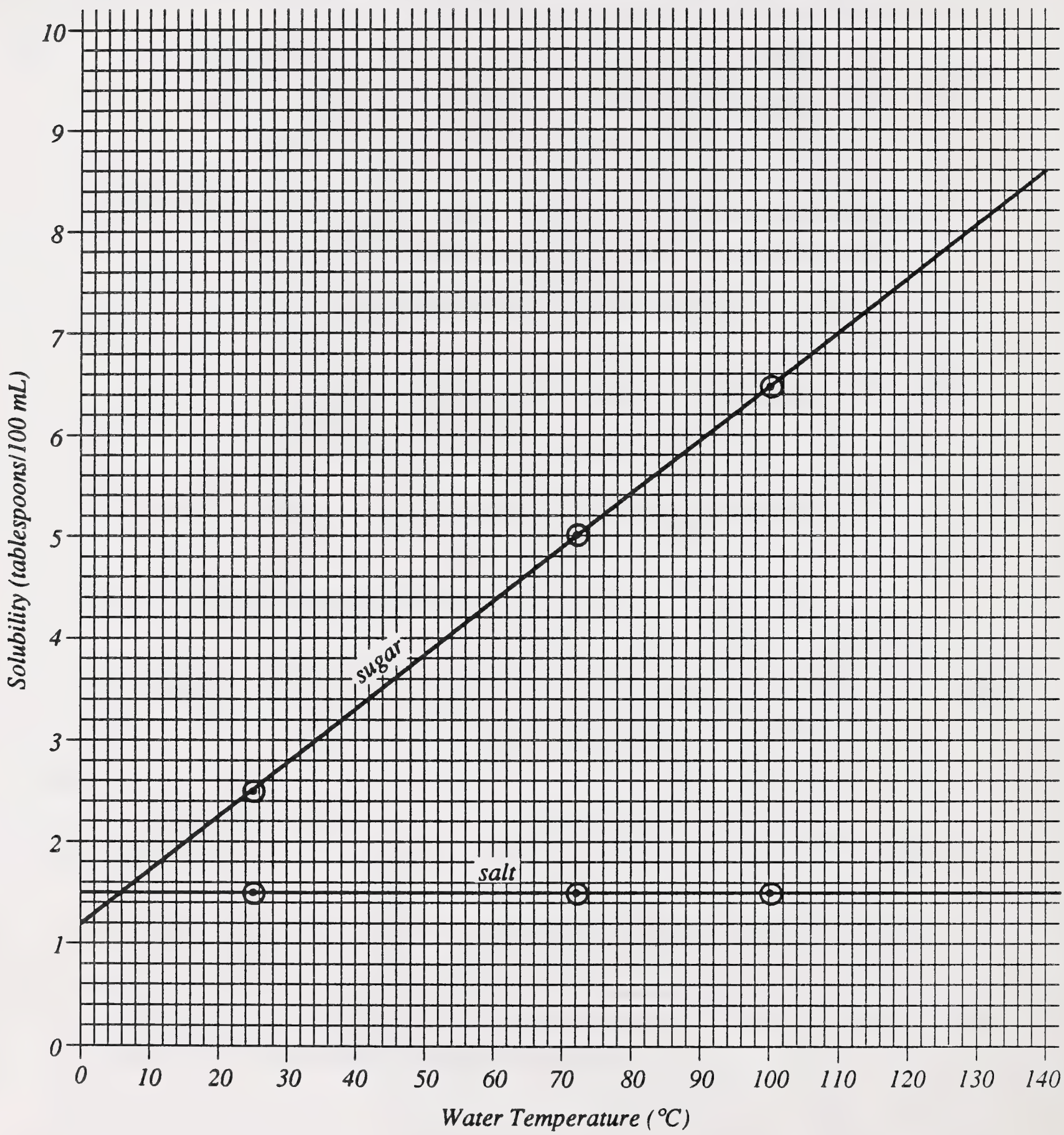
Water Temperature (°C)	**Solubility of Salt (tablespoons/100 mL)**
25	*1.5*
72	*1.5*
100	*1.5*

b.

Water Temperature (°C)	**Solubility of Sugar (tablespoons/100 mL)**
25	*2.5*
72	*5.0*
100	*6.5*

9. Use your charts to construct two curves on the following graph. Label each curve.

Title: *Effect of Temperature on Salt and Sugar Solubility*



10. Explain what your graph tells you about the solubilities of the two solutes you experimented with.

    The solubility of salt only increases about 4 g /100 mL between 0 and 100 °C. A tablespoon measurement will not show a change this small. Student graphs for salt will be either a horizontal line or a line quite similar to that. Sugar's solubility changes significantly with temperature increases. Student graphs should show the sugar solubility curve rising quite rapidly to the right side of their graph paper. At low temperatures the solubility of sugar and salt is similar.

Section 3: Follow-up Activities

Extra Help

Water Temperature (°C)	Solubility of Potassium Chloride (g/100 mL)
10	31
20	34
30	37
40	40

Use the preceding chart to answer the following questions.

1. What is the solubility of potassium chloride at 30°C? Be sure to include solubility units and temperature.

   The solubility of potassium chloride is 37 g /100 mL at 30 °C.

2. Give an example of a concentration for potassium chloride that has not reached the saturation point. Be sure to include solubility units and temperature.

   The answers will vary. The concentration must be less than the solubility for the temperature. For example, at 10 °C any concentration less than 31 g/100 mL is correct. At 20 °C any concentration less than 34 g/100 mL is correct.

   Refer to the solubility chart for potassium chloride to answer the following questions.

3. What are the manipulated and responding variables shown?

   On the potassium chloride chart the manipulated variable is the temperature, and the responding variable is the solubility of potassium chloride.

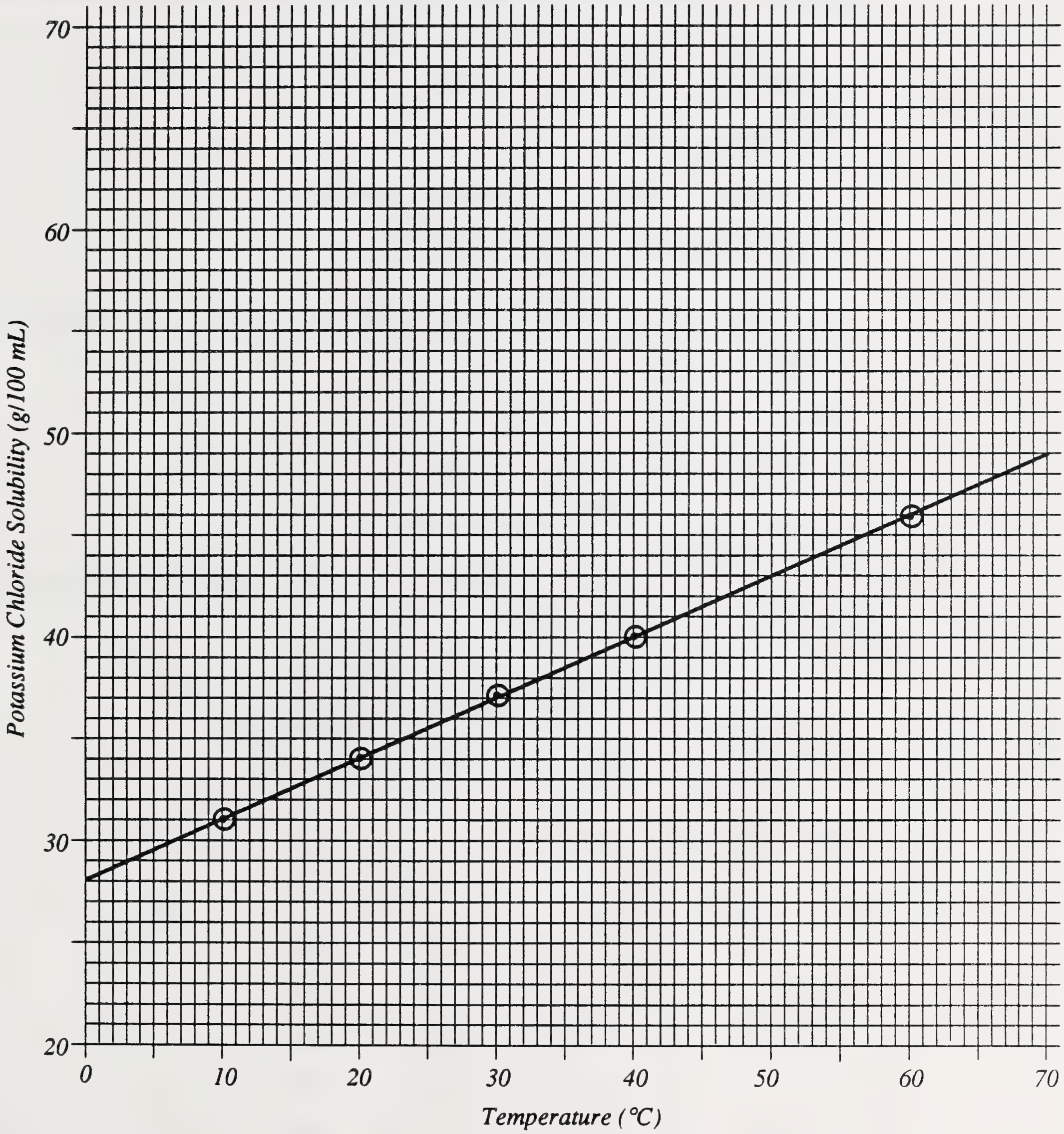
4. What controlled variable is very important to consider in determining temperature's effect on the solubility of potassium chloride?

   Since solubility is measured by the amount of solute per 100 mL, the amount of water used in each trial must be the same.

5. Using these graphing rules and the data table, complete the following graph.

Water Temperature (°C)	Solubility of Potassium Chloride (g/100 mL)
10	31
20	34
30	37
40	40

Title: *Solubility of Potassium Chloride at Different Temperatures*



Enrichment

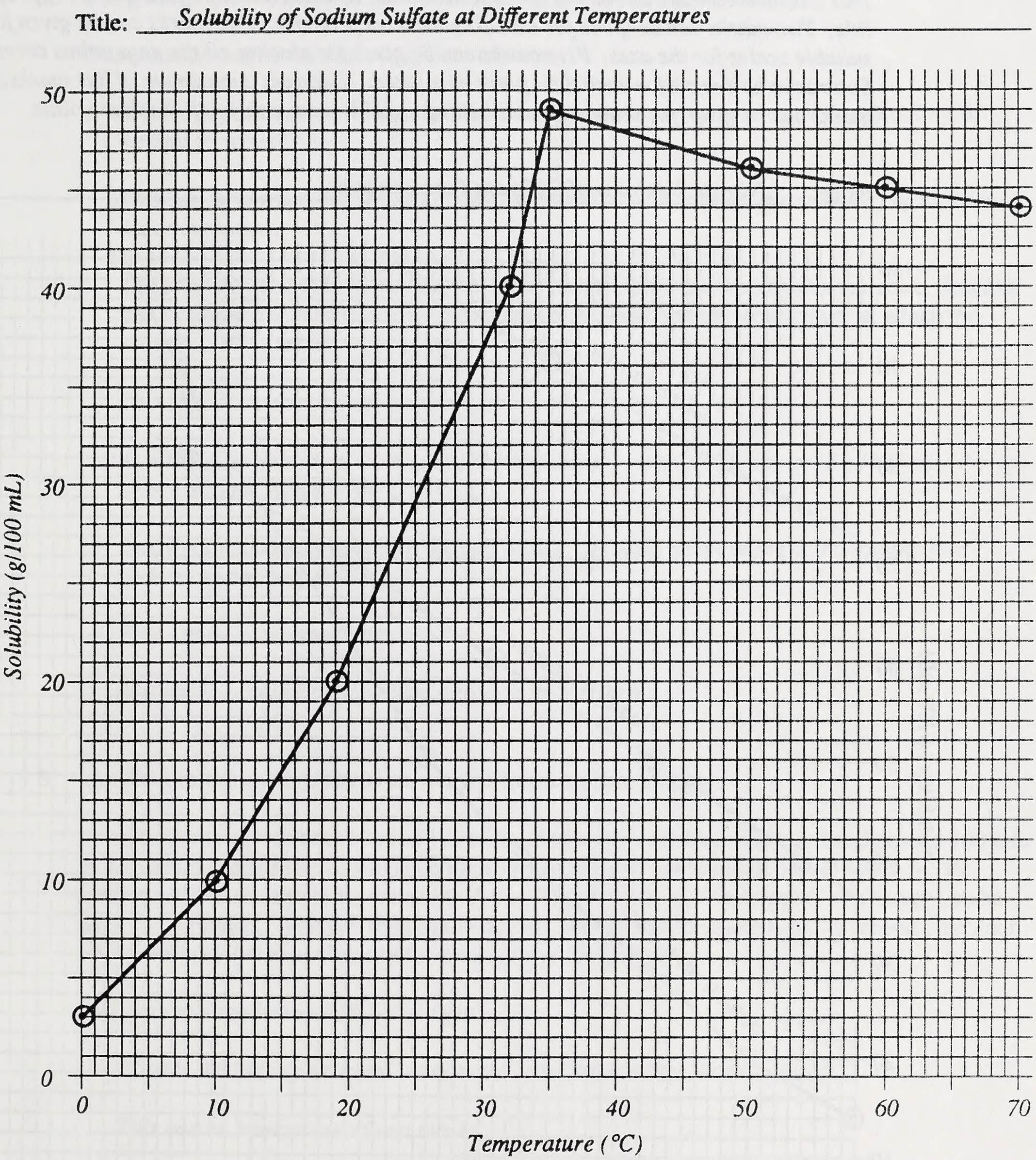
1. In this section you made a graph following a set of rules. What were the rules you had to follow to graph your data?

   Answers will vary. A sample answer follows.

   - *Give the graph a title.*
   - *Reserve the horizontal axis for the manipulated variable.*
   - *Place the responding variable on the vertical axis.*
   - *Include the manipulated and responding variable names on the appropriate axis of the graph. Write the units for each variable in brackets after each name.*
   - *Circle the points you plot on the graph.*
   - *Connect the points you plot with a straight line or smooth curve.*
   - *Cover at least half of your graph paper with the graph.*

2. Sodium sulfate has an unusual solubility curve. Using the graphing rules and the data table, graph the solubility of sodium sulfate.

Water Temperature (°C)	Solubility of Sodium Sulfate (g/100 mL)
0	3
10	10
19	20
32	40
35	49
50	46
60	45
70	44

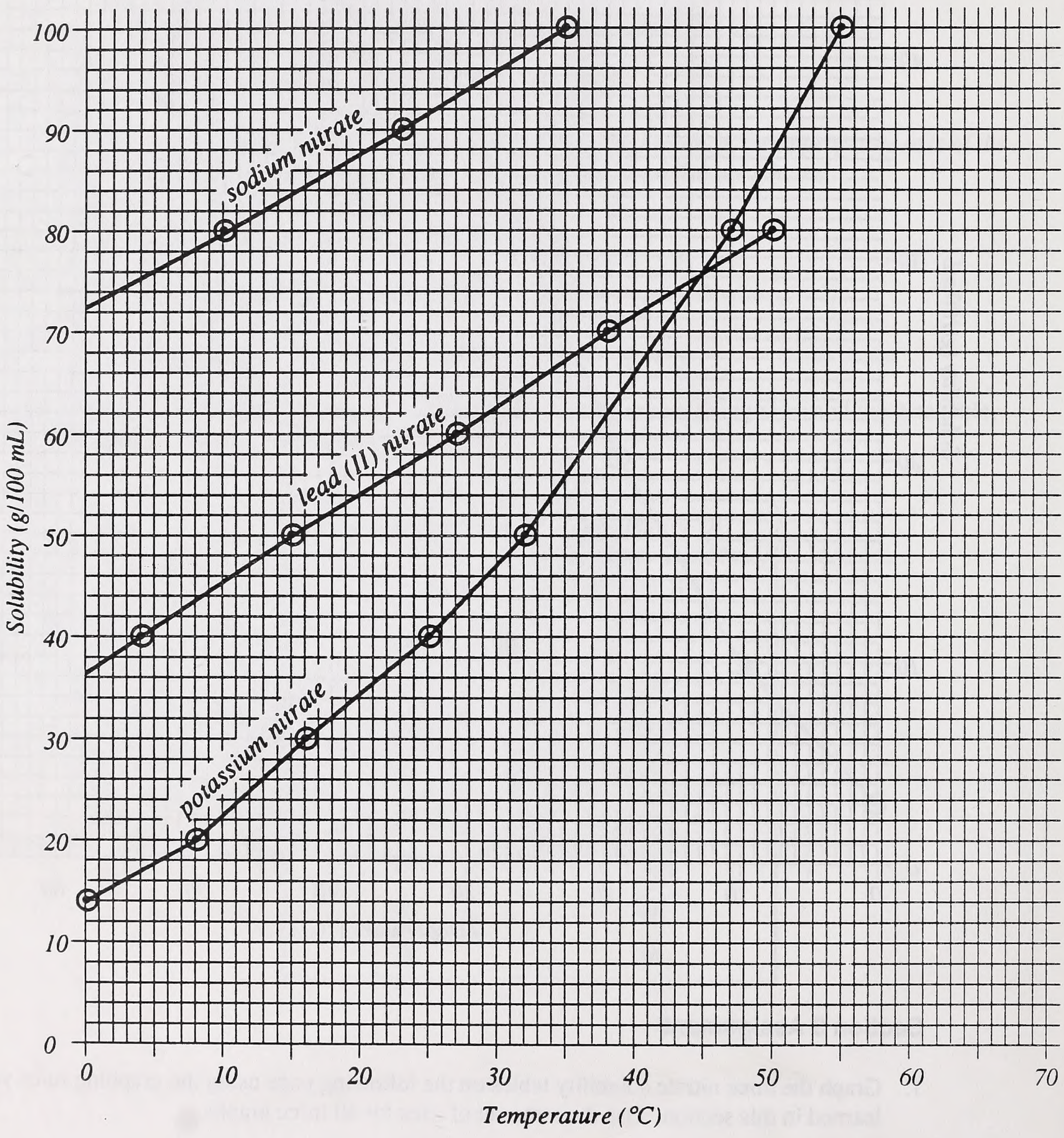


Section 3 Assignment

1. Graph the three nitrate solubility tables on the following page using the graphing rules you learned in this section. Use the same set of axes for all three graphs.

This question can be marked out of thirteen marks. One mark can be given for an appropriate title. Two marks can be given for labelling the axes properly. Two marks can be given for using suitable scales for the axes. Five marks can be given for placing all the data points correctly. Subtract a half mark for each data point misplaced. (Subtract a maximum of five marks.) Three marks can be given for drawing and labelling suitable curves through the data points.

Title: *Nitrate Solubility of Different Temperatures*



2. Using the graph you made in question 1, answer the following questions.

   This question can be marked out of seven marks.

   a. What can you conclude about the relationship between temperature and the solubility of nitrates in water?

      This can be marked out of two marks. As temperature increases, the solubility of nitrates in water increases.

   b. The solubility in liquid water for two of the nitrates is the same at one temperature. Explain this by giving the nitrate names, the solubility reading, and the temperature at which the solubility is the same.

      This can be marked out of four marks.

      At 46°C the solubility of both lead (II) nitrate and potassium nitrate is 78 g /100 mL. Accept answers in the range of 44°C to 48°C.

   c. Study your solubility curve for sodium nitrate. At what temperature is the solubility of sodium nitrate 96 g /100 mL?

      This can be given one mark.

      At 30°C the solubility of sodium nitrate is 96 g /100 mL.

3. Use the following paragraph to answer the questions that follow.

   Late one morning a scientist boiled 1 L of distilled water. He then measured and poured 100 mL of water into each of two identical containers. To the first container he added solute A. He determined that the solubility for solute A was 25 g /100 mL. The scientist was hungry, so he went out for lunch. When he returned two hours later he added solute B to the second container. He determined that the solubility for solute B was 20 g /100 mL.

   This question can be marked out of eight marks.

   a. What is the inquiry problem (or question) that the scientist was studying?

      This can be marked out of two marks.

      The answers will vary, but the problem statement must include the manipulated variable (type of solute) and the responding variable (solubility). A sample answer follows.

      What effect does the type of solute have on the solubility?

b. Using the data presented, what would the scientist's inference be?

This can be marked out of two marks.

Answers will vary. The response must answer the question posed by the problem, and it must use the data presented. A sample answer follows.

Solute A has a higher solubility in water than solute B.

c. Would this inference be valid? Explain why or why not. If not, what change in procedure needs to be made?

This can be marked out of four marks.

Answers will vary. The response should indicate the following:

- *that the inference is invalid (one mark)*
- *that the water temperature was not controlled (one mark)*
- *how to control the water temperature (e.g., make sure the water temperature is the same for both trials or find the solubility at several temperatures for each solute and graph the results) (one mark)*

If a student has received three marks so far, one mark may be given for language usage. If a student has received less than three marks, no language usage mark needs to be given.

4. What is the difference between mixing and dissolving?

This question can be marked out of two marks.

Students have been studying homogeneous and heterogeneous mixtures in this unit. The term "mixing" can be used when either type of mixture is produced (one mark). Dissolving only occurs when homogeneous mixtures are produced (one mark).